Exploiting quantum parallelism to simulate many-body quantum random systems

Abstract: We present an algorithm that exploits quantum parallelism to simulate randomness in a quantum system. In our scheme, all possible realizations of the random parameters are encoded quantum mechanically in a superposition state of an auxiliary system. We show how our algorithm allows for the efficient simulation of dynamics of quantum random spin chains with known numerical methods. We also propose an experimental realization based on atoms in optical lattices in which disorder could be simulated in parallel and in a controlled way through the interaction with another atomic species.